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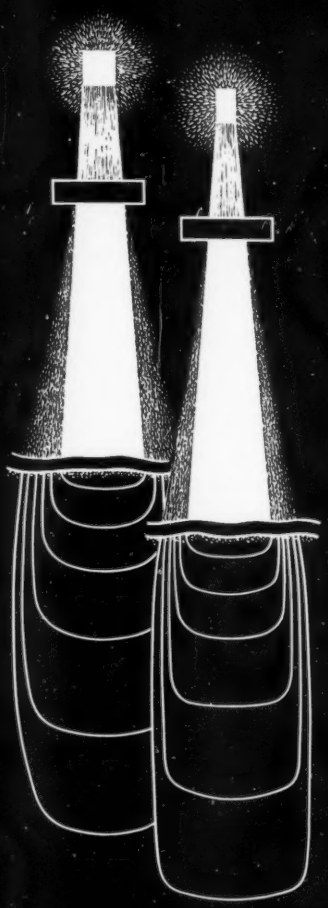

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EDITORIAL

TWO SPECIALTIES IN ONE

With advancing knowledge, the two major sub-specialties in radiology — Diagnosis and Therapy — tend to find themselves more and more separated. Much honest difference of opinion exists across the country as to whether this tendency to divide what was once one specialty into two separate disciplines is good or bad. Those who wish to make the division more complete have many strong arguments. With more specialized knowledge required, even the "pure" diagnostic radiologist finds himself almost a general practitioner in diagnosis, having to deal with many specialists in their own fields, and hard pressed to keep up with them all. The same can be said of the therapist, who is increasingly in danger of spreading his efforts so thinly over a wide variety of endeavours, including work with radioisotopes, high energy radiation sources, and clinical oncology, that he cannot be satisfied with his efforts in any one direction. Even the radiologist who devotes most of his time to a particular interest in the field, as for example pediatric diagnosis or pediatric therapy, finds that what appeared initially to be a small or even narrow area of interest, has become vast and demands all of his energies. On the positive side, one can point to the excellent work being done by therapists who have never been trained in or attempted to do diagnostic radiology, and vice versa. And to find the man doing original work, the radiologist who is actively engaged in research, one must almost invariably go to the completely independent department of therapeutic or of diagnostic radiology. The need to restrict one's practice in order to do the best work is evident throughout medicine, and would appear to apply equally to radiology.

In this country the therapists have, it seems fair to say, the additional problem of being almost overwhelmed by the numerical predominance of diagnosticians. In the hospital departments, at the mixed scientific meetings, and specifically in the Canadian Association of Radiologists, the radiation therapist feels himself at a disadvantage because of sheer weight of numbers. Compared with diagnosticians his scientific papers are likely to be read to a discouragingly small audience, and in the business meetings of the Association and its Council, his problems at times appear to occupy a small part of the agenda and of the discussion.

Nevertheless there appear to be very few radiologists in the country who wish to see the two groups finally and completely divided. Some of this reluctance to permit complete partition is admittedly due to sentiment — the diagnostic and the therapeutic radiologists have met and worked and argued together for so long that a tremendous mutual respect and regard has been built. Some of it is simply old fashioned; the man who has trained and practiced as a general radiologist for many years finds it hard to believe that others cannot follow where he has led, much as a general surgeon of long experience hates to relinquish, bit by bit, parts of the broad practice which together made up a fascinating and challenging field. Finally there is the concept of the need in the small or medium sized community for a radiologist who is capable of both diagnosis and therapy. The increasing availability of means of transportation to superbly staffed and equipped treatment centres in larger communities has, however, somewhat weakened this argument for the continuing dual role of the radiologist.

There remain some hard and practical considerations in favour of a continuing close association of the two groups. To train a diagnostic radiologist without help from the therapist is to deprive him of essential knowledge of the interaction of radiation and matter. To train

him without the help of a physicist is impossible, and the physicists tend to associate themselves, rightly and understandably, with radiation therapy. The diagnostic radiologist is demonstrably of more service to his colleagues if he knows a great deal about the natural history of malignant disease, and about the possibilities and limitations of radiation therapy; these things are best learned in a therapeutic department. The therapist in turn must know something about diagnostic radiology, since in every-day practice he bases much of his concept of the site and extent of new growth on X-ray films. Finally, not the least of the hard realities which continue to unite the two groups are those of medical economics. Although all the specialties in medicine try to work together and to keep themselves mutually informed, the problems, possibilities and opportunities confronting the two major groups in radiology have so much in common that much strength and support is derived from their closest possible association in every-day practice and in meetings.

So it seems very unlikely that the differences which tend to divide us will, at least in the near future, sever the bonds which unite us. There is, however, one practical step that can be taken and which we think will commend itself to the thoughtful teacher in radiology. A candidate for post-graduate training in radiology must have the facts of the "two specialties in one", and the differences of opinion about how "general" a good radiologist can be, explained to him before he commits himself irrevocably to a course of training. The student beginning to study radiology is full of hope, eager to learn, and easy to influence. It is only fair that the present situation be discussed with him at the outset, with the limitations inherent in the broad, as well as in the highly specialized, training and practice clearly presented. No one can be trained as broadly and thoroughly as he would like, or as his teachers would wish. Some sacrifices, some compromises, have to be made. The man who in three, four, or five years is going to present himself as a candidate for a certificate which states that he is a qualified radiologist, deserves to be given as clear a view of what lies ahead of him as possible.

J. S. D.

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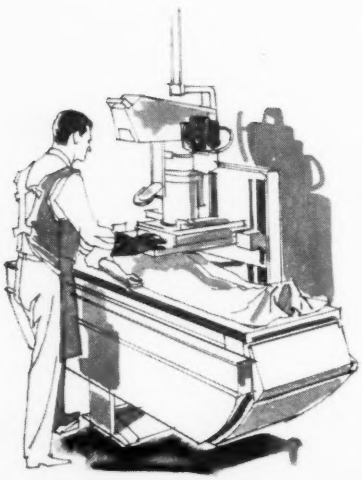

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THE RADIOLOGIC FEATURES OF BONE CHANGES IN TUBEROUS SCLEROSIS WITH A CASE REPORT *

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The purpose of this paper is to describe the radiologic features of tuberous sclerosis, with particular reference to the bone changes.

The occurrence of changes in the viscera and bones is well known; but several of the bone lesions with their incidence, their distribution and their combination are perhaps less well known. The combination of certain bone changes, in the presence of lesions in the brain, is virtually diagnostic of the disease. One case report is presented which illustrates many radiologic features.

It is not proposed to add to the excellent historical reviews made by other authors[9,13,24]. Much credit has been given to Bourneville[10] for his description of tuberous sclerosis in 1880. It had, however, already been recognized by von Recklinghausen[30] 17 years before. The classical triad of adenome sebaceum, mental retardation and epilepsy was soon established as a clinical entity. The term "sclérose tubéreuse" was coined to indicate the nodules resembling raw potato which were found in the brain.

Etiology

It is generally agreed that tuberous sclerosis is a developmental anomaly in which hereditary factors play a major rôle. The precise mode of inheritance is not entirely clear. Most writers consider that the disease is caused by a single autosomal dominant gene with a variety of manifestation[9]. A few writers consider that the disease may be recessive (90.4% of 125 cases had "normal" parents[35]): however, since it is known that the gene may be transmitted as a dominant, mutation may account for the sporadic cases.

Incidence

About 0.6% of patients in institutions for the epileptic and the mentally defective have tuberous sclerosis[9].

It has been calculated that in the general population, tuberous sclerosis in *all* its forms, will occur in about 1 per 150,000[13]. It occurs about 18 times less frequently than neurofibromatosis[21].

Sex distribution is almost exactly equal[35].

Pathology

Tuberous sclerosis belongs to a category of disorders in which the basic lesion is a defect in histogenesis and organization of tissues, with a tendency to formation of hamartomata. These hamartomata are tumor-like formations of disorganized, well differentiated tissue, usually composed of the same cellular elements as the organ in which they occur.

In the kidney of tuberous sclerosis these lesions are very commonly found at autopsy, and show great variety in the predominant tissue, so much so that they may be regarded as variations on a theme of "myofibrolipoangioma"[34].

The disease is related to other diseases in the group of congenital neuroectodermoses (phacomatoses), which affect primarily the structures of ectodermal origin and to a lesser degree the structures of mesodermal and endodermal origin; these include:

Neurofibromatosis (von Recklinghausen's disease)
Cephalotrigeminal haemangiomatosis (Sturge-Weber disease)
Cerebelloretinal haemangiomatosis (von Hippel-Lindau disease).

Clinical Picture

In addition to the classical and florid cases there are many milder variations and abortive forms (formes frustes), which often present in later life with some of the more usual features, e.g., mental retardation, absent. It is in these abortive forms where the diagnosis cannot be .made on clinical

* *Presented at the Annual Meeting, The Canadian Association of Radiologists, January 25, 1960, Toronto, Ontario.*

grounds alone, that the radiologic features are of most value. Also, in the investigation of epilepsy and mental deficiency, a number of cases of tuberous sclerosis may be brought to light by radiologic examination.

Laboratory investigations are of singularly little value in diagnosis.

Radiologic Findings

The radiologic features of tuberous sclerosis may be classified as follows:

IN VISCERA:

1. *Brain*

(a) Calcification in 80% (of 25 patients)[31]. The youngest recorded patient was 4½ years of age[7].

Forms:

(i) nodular: this form is much the commonest; the areas are multiple, discrete, several millimetres across, and are seen mainly in the region of the third ventricle and basal ganglia[31,37], and occasionally in the dentate nucleus of the cerebellum[21].

(ii) linear; usually sinuous[26,34]. This is uncommon.

(iii) single large calcified mass, e.g., about 2.5 cms. in diameter[2,12,28]. This is uncommon.

(b) Encephalographic changes:

(i) brain atrophy or hypoplasia in 80% (of 20 patients studied)[31]. This produced symmetric enlargement of the ventricles in 16 out of the 17 cases in which it occurred.

(ii) focal deformities[6,20,24,31,34] (include "candle guttering" in 35% of 20 patients studied by encephalography[31]; this sign is due to small nodules arranged in linear fashion on the lateral wall of the third ventricle).

(iii) obstructive phenomena[20,24,34,38], e.g., internal hydrocephalus; this is rare.

2. *Kidney:*

Tumor-like nodules can occur in as many as 80% of 26 cases at autopsy[22]. During life these may be revealed as —

(a) Abnormal renal contour.

(b) Compression defects of the renal collecting system.

(c) "Reticulation" of the renal shadow: this has been described in one case[4], and was ascribed to the high fat content of the tumor. This might be of value in differentiation from polycystic disease of the kidney.

3. *Eye:*

Intraoccular tumors (phacomata) in as many as 24% of 25 cases[31]. These lesions have not been reported to show calcification on the radiograph.

4. *Lung:*

Changes in the lung are uncommon, but where they have been observed, radiographs of the bones have shown characteristic lesions[13]. The lung changes comprise: —

(a) Multiple cysts, producing reticular, miliary or honeycomb appearance on the radiograph[5,29]. Spontaneous pneumothorax may be a prominent feature.

(b) Increase in interstitial lung tissue, in which smooth muscle is a very prominent feature[5,29,36]. This has been called a "myofibrosis."

5. *Other viscera:*

For example, heart and liver, may contain tumor-like formations which may be revealed as an abnormal contour.

IN BONES:

1. *Hands and feet:*

Changes were seen in 66% (of 30 patients[21].)

Commonly:

(a) Metatarsals and metacarpals show subperiosteal new bone formation giving an undulating contour. This change is most common in the 2nd, 3rd and 4th metatarsals[37].

(b) Phalanges:

(i) cyst-like lesions, especially in the terminal phalanges[15]. Of 18 patients with radiographs of the hands, 5 showed cyst-like lesions in the phalanges, and a sixth patient showed one in a metacarpal[31].

(ii) cortical pitting (a term suggested by Hawkins[19]) and "cortical fragmentation", where several pits have apparently become confluent[16,19,21].

These areas are sharply defined radiolucencies confined to the cortex; they vary widely in size, shape and depth. The adjacent cortex may be thickened. The shaft rarely is widened.

Rarely:

(iii) generalized demineralization of the phalanges and sometimes of the metacarpals[16,33].

(iv) subperiosteal new bone in phalanges. This has been described

in a few cases[7,16,17], and is also present in the case report appended.

2. *Skull Vault:*

Commonly:

(a) Patches of increased bone density in 48% (of 25 patients)[31]. These occur most commonly in the upper half of each parietal bone. These bony changes are not always adjacent to the underlying brain nodules[21], as was once thought.

(b) Thickening and increased radiodensity of both tables which may be regional or generalized[16,17].

Rarely:

(c) Areas of demineralization surrounding the areas of increased density. This has been described in one case only[16]. The base of the skull has shown changes, comprising thickening of the petrous bones and appearance of overgrowth of bone, described in one case[17].

Possible Association:

Dilated venous channels (case No. 1 of Hall)[17].
Microcephaly (case No. 7 of Berland)[7].
Asymmetric skull (case No. 3 of Whitaker)[37].

3. *Pelvis and Spine:*

(a) Patches of increased bone density have been described several times[3,4,26,27,31,37].

(b) Cyst-like lesions have been described in one case of tuberous sclerosis in which some features resembling those of neurofibromatosis were also present[1].

4. *Long Bones:* also are less commonly involved than the skull and extremities. The changes which have been described include:

more commonly:

(a) Irregular subperiosteal new bone formation, tending to involve the greater part of the shaft[13,29,37].

less commonly:

(b) Small subperiosteal nodules of new bone formation — these may be an early stage of 4 (a) above[19,29,34].

(c) A patch of increased bone density, irregular and fairly well defined, probably in the cancellous portion of a long bone. This has previously been recorded once[32], and occurs in the patient described below.

(d) Cyst-like or "fibrocystic" changes; these have been described in very few cases of clear-cut tuberous sclerosis[13,17,18].

5. *Ribs:* Changes have been described in only 4 cases, according to this review[8,11,37].
The type of change includes:

(a) Generalized thickening (case No. 3 of Whitaker[37], and also in the patient described below).

(b) Subperiosteal new bone formed in irregular wavy fashion[11].

(c) "Fibrocystic" expansion of a rib (case No. 2 of Whitaker[37]).

To date, the facial bones, mandible, hyoid, clavicles, scapulae, sternum, carpals and tarsals have not been reported specifically to show lesions. The patient to be described has areas of increased bone density in the left cuboid and in the sternum, which are almost certainly lesions of tuberous sclerosis.

Differential Diagnosis

If each lesion is considered individually, e.g., brain calcification, a formidable list can be drawn up. However, the type of individual lesion in tuberous sclerosis has fairly well recognizable forms and since the disease is characteristically widespread through the body, the demonstration of other lesions and their combination usually allows of a precise diagnosis.

It should be noted however, that from the radiologic aspect, calcification in the brain has been recorded no earlier than at the age of 4½ years[7]. Also, from the literature reviewed, the impression is gained that bone lesions are not often encountered until puberty is approached; this impression, however, must be regarded in the light that the great majority of patients recorded were past puberty when first studied.

One important differential diagnosis may perhaps be considered in more detail, viz., that of the patchy areas of increased density being compared with osteosclerotic metastases. In this instance, the individual lesions and their distribution may be similar in the two conditions. But, in tuberous sclerosis, there are almost always bone changes of another type, e.g., characteristic subperiosteal new bone or cyst-like lesions, co-existing with these patches of increased density. Also, brain calcification or other stigmata will differentiate the two conditions with reasonable certainty.

CASE REPORT:

A white woman aged 40 years, had had focal seizures and adenoma sebaceum since the age of 2 years. Her childhood was otherwise normal and she completed a high school education. Her family history revealed no definite suspicion of any condition related to the above symptoms. She came to the Montreal General Hospital with a history of 8 years of fatty food intolerance, 6 years of menorrhagia, and 1 year of dysmenorrhea culminating in menorrhagia for 18 days, and finally, abdominal pain and fever. Physical examination revealed no evident mental retardation. She was

moderately well developed. Adenoma sebaceum was present, and the possibility of tuberous sclerosis was raised. Curettage of the uterus showed proliferative endometrium with fibroadipose tissue on its deep aspect and in the adjacent myometrium (in retrospect this may have been a hamartoma).

A barium series, although it showed no abnormality of the upper gastrointestinal tract, did reveal multiple bone lesions.

Laboratory data

Urine: normal. Haemogram: haematocrit 38%. E. S. R. 12 mms hr.
Total serum proteins: 8.2 gms 100 cc. (A G $= \frac{3.8}{4.4}$)
Serum calcium: 9.2 mgms 100 cc. Serum phosphorus: 3.9 mgms 100 cc.
Serum bilirubin: 0.2 mgms 100 cc.
Alk. phosphatase: 23 u. and later was 7 u. (King-Armstrong), perhaps due to the multiple gall stones which the patient was known to have.
B.U.N.: 16 mgms 100 cc. W.R.: negative.
ECG.: "no focal anomaly: slight slowing of main rhythms."

Radiologic study

Intravenous pyelogram showed bilateral multiple parenchymal renal tumors. "Reticulation" of the renal shadows was absent.

Skeletal survey revealed: Multiple nodular calcifications in the brain, concentrated in the region of the basal ganglia. The skull vault showed a generalized thickening and increased density (which may well be due to tuberous sclerosis). The spine showed patches of increased bone density in cervical, thoracic and lumbar regions. The innominate bones, sacrum and right femur also showed patches of increased density. The right tibia and fibula, and right radius and ulna showed subperiosteal new bone formation in fairly extensive undulating fashion, confined to the diaphysis. There were subperiosteal nodules of new bone on the right tibia, (which have been described in only three cases previously)[19,34].

There was extensive subperiosteal new bone formation around the shafts of all the metacarpals and metatarsals.

Several cyst-like lesions were noted in the phalanges, mainly in the terminal ones. Cortical pitting was seen in several phalanges of both hands and both feet.

Subperiosteal new bone formation was present around the shaft of the proximal phalanx of several fingers and one toe, (this has been described in only two other cases)[16,18].

The left cuboid bone showed a patch of increased density which may well be a lesion of tuberous sclerosis (this has not previously been described in the tarsus).

The chest radiographs showed no definite abnormality in the heart or lungs, but the sternum showed an area of increased bone density in the region of the 2nd and 3rd segment of the gladiolus, with thickening of cortical bone on the endosteal surface of both the anterior and posterior cortex. This is almost certainly a lesion of tuberous sclerosis, which has not hitherto been reported in the sternum.

Discussion

The pathologic nature of the bone lesions is as yet obscure. Jaffe states: "So little information is available about the actual pathology that a decision must be held in abeyance"[23].

In the literature reviewed, there have been only four well-documented pathologic descriptions of bone lesions in clear-cut cases of tuberous sclerosis[14,15,19,25]. The first was a patch of increased bone density in the skull vault and showed, in essence, great reduction in narrow spaces of the diploe, owing to concentric development of bone on previous trabeculae.

The second specimen was of the terminal phalanges of one hand, and the reports of two pathologists were published[15] and may be summarized:

(i) Areas of replacement of bony by dense collagenous tissue mingled with adipose tissue, with adjacent thickening of cortical and cancellous bone. It appeared to be a chronic process.

(ii) Focal resorption associated with a proliferative process in which very abundant osteoid was formed along otherwise normal trabeculae.

The osteoid tissue calcified less readily than usual, but resulted in the slow formation of trabecular bone in a bizarre architectural pattern. Cyst-like areas were composed of tightly packed collagen. There was no suggestion of neurofibromatosis or of neoplasm.

Another microscopic report is from the bones of several digits of the hand of a patient with widespread advanced tuberous sclerosis[18]. Several of the bones examined were enlarged, deformed and markedly rarefied. Microscopy showed extensive vascularity and rarefaction with a prolific immature form of ossification of the intramembranous type. The periosteum over the lesion was replaced by an avascular and relatively acellular felt-work of connective tissue, into which ossification extended irregularly from the surface of the bone. Transition from normal to abnormal was abrupt in most places.

Various theories of pathogenesis have been proposed. Those which apply to the above histological changes include:

(i) that a local deficiency in periosteum produces defective control of appositional growth[18].

(ii) that a local circulatory disturbance occurs as a result of a postulated neurocirculatory disturbance in the bone[18].

(iii) a further consideration is proposed, which has hitherto been unmentioned in the literature reviewed. When the nature of tuberous sclerosis is considered it is seen that the basic defect is one of organization of tissue, with a tendency to formation of hamartomata. It is possible that some of the bone changes as demonstrated on the radiographs may, in fact, be hamartomata of bone. This proposal, however, does not explain the distribution, frequency or combination of the lesions, nor does it explain the lack of dental anomalies; in the literature reviewed, there was no recorded lesion of the teeth which could be ascribed to tuberous sclerosis.

Figure 1 — Nodular intracranial calcification is seen in the region of the basal ganglia. Slight hyperostosis of the vault is present.

Figure 2 — Extensive subperiosteal new bone formation is seen in undulating fashion in the metatarsals. An increased density, which may be a lesion of tuberous sclerosis, is seen in the cuboid.

Figure 3 — Subperiosteal new bone is present in the metacarpals, and in several phalanges. Cyst-like lesions in the terminal phalanges, and cortical pitting in other phalanges, are also seen.

Figure 4 — Multiple compression defects are seen in the collecting systems of both kidneys. The contour of the right kidney shows a tumour formation.
Multiple areas of bone sclerosis are seen in the pelvis, sacrum, and lumbar spine. The right eleventh rib shows generalized enlargement and increased radiodensity.

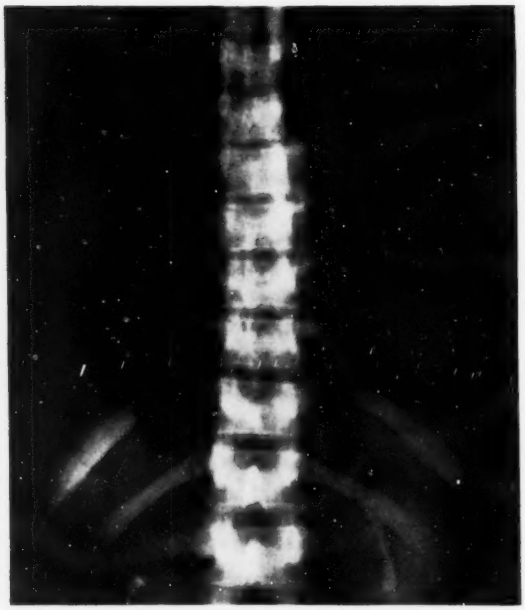


Figure 5 — Areas of increased density are present in the vertebrae.
The right eleventh rib shows increase in size and radiodensity.

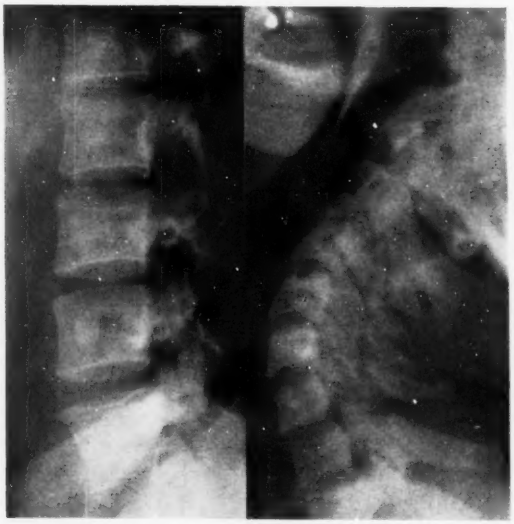


Figure 6 — Patches of increased bone density are present in the vertebrae.

Figure 7 — Areas of increased radiodensity are present in the cervical spine.

Figure 8 — Subperiosteal new bone is seen in undulating fashion in the shafts of the tibia, fibula, radius and ulna. Subperiosteal nodules of bone are seen in the shaft of the tibia.

Figure 9 — The sternum and thoracic vertebrae show patches of increased radiodensity. The right 11th rib is thickened.

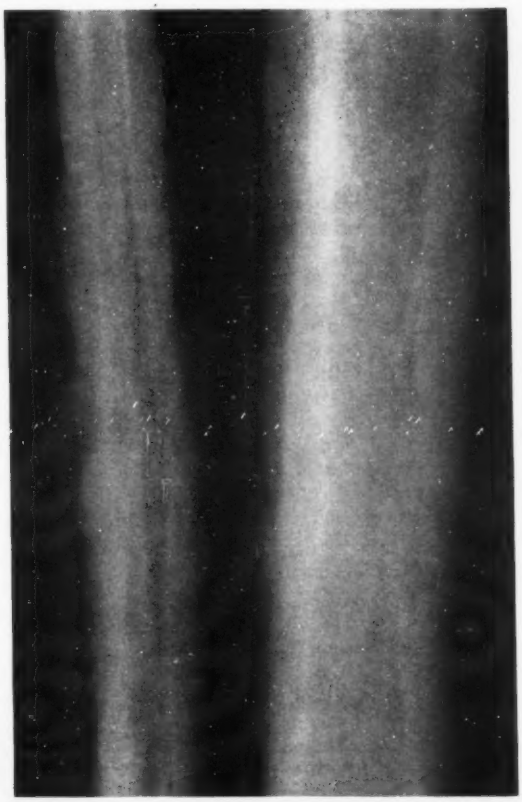
Figure 10 — Detail view of changes in the extremities.

Figure 12 — Detail view of tibia and fibula.

Figure 11 — Detail view of changes in a phalanx.

Figure 13 — An area of increased radiodensity is seen in the shaft of the femur.

Figure 14 — Detail view of the changes in the sternum.



Summary

The radiologic features of tuberous sclerosis, with particular reference to the bone changes, have been described.

The frequency, distribution and combination of bone changes have been discussed.

The combination of bone changes, in the presence of brain lesions, is virtually diagnostic of the condition.

It is suggested that, in the investigation of epilepsy, mental deficiency, and possible abortive forms of tuberous sclerosis, radiographs of the extremities and the skull may be of considerable diagnostic value.

A selective review of the literature has been made from the radiologic aspect.

One case report, which is remarkable for its illustration of many radiologic features, is presented.

The nature of the disease, and possible influences in the pathogenesis of the bone lesions, have been discussed.

Résumé

L'auteur expose le tableau radiologique de la sclérose tubéreuse en insistant particulièrement sur les atteintes osseuses. Il discute de l'incidence, de la localisation et des associations de ces lésions osseuses. La coexistence de lésions dans les os et le cerveau est presque pathognomonique de cette entité. L'auteur considère d'un important apport diagnostique la prise de clichés des extrémités et du crâne au cours des investigations pour épilepsie, retard mental et des formes frustes possibles de la sclérose tubéreuse.

Une revue élective de la littérature du point de vue radiologique complète la présentation.

Un cas démonstratif par ses caractéristiques radiologiques accompagne cet exposé.

L'auteur discute de la nature de la maladie et des facteurs pouvant influencer la pathogénie de ces lésions osseuses.

ACKNOWLEDGMENTS : My thanks are due to Dr. F. C. Fraser for his contribution to the genetic aspect of tuberous sclerosis and to Drs. D. J. Sieniewicz, J. Scott Dunbar and D. W. MacEwan for their helpful criticism and advice.

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THE ERECT LATERAL PROJECTION OF THE PELVIS: AN ASSESSMENT OF ITS VALUE AS AN INITIAL PROCEDURE IN PELVIMETRY *

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Within the past few years the hazards inherent in radiation damage to the maternal ovaries and fetus in obstetrical radiology have been a matter for increasing concern, particularly to radiologists on whose shoulders the burden of responsibility must lie. Much has been done recently to reduce radiation exposure by the use of high speed film and screens, high kilovoltage and by other technical measures. However, little attention has been paid to the reduction in radiation which is made possible by decreasing the number of exposures necessary for accurate evaluation of the obstetrical pelvis. Recently we have become impressed by the number of patients who clearly show absence of disproportion on the single erect lateral film of the pelvis, without antero-posterior or inlet views. This observation has prompted us to review a series of pelvigrams selected at random from our files with the intention of determining in what percentage of cases an accurate prediction of a normal delivery could be made from the single erect lateral film of the pelvis.

Method of Investigation

A total of 317 pelvigram examinations made at the Royal Victoria Hospital from 1954 to 1958 were reviewed. In each case the lateral film alone was examined and an opinion recorded as to whether an uncomplicated vaginal delivery would take place, or whether the findings were such as to warrant a complete pelvigram study. For purposes of completeness, each of the 317 cases was again reviewed but this time with the benefit of the full pelvigram technique as recommended by Thoms (this includes a single AP film of the abdomen and pelvis, a supero-inferior projection of the pelvic inlet and an erect lateral film of the pelvis). On the basis of the full pelvigram study one of the following predictions was made:

(a) Absolute cephalo-pelvic disproportion necessitating caesarean section.
(b) Borderline cephalo-pelvic disproportion of the inlet necessitating trial of labour.
(c) Lower pelvic strait disproportion necessitating forceps delivery.
(d) No disproportion; uncomplicated vaginal delivery predicted.

Technique of Assessment

The erect lateral film of the pelvis reveals the following information:

1. The shortest antero-posterior diameter of the inlet, measured from the postero-superior border of the symphysis pubis to the nearest point on the anterior border of the 1st segment of the sacrum.
2. The antero-posterior diameter of the outlet, measured from the postero-inferior border of the symphysis pubis to the lowest fixed segment of the sacrum (or coccyx, if fused).
3. The shape and inclination of the sacrum and coccyx, including special note of a prominent sacro-coccygeal shelf where present.
4. The width and contour of the sacro-sciatic notch.
5. The depth of the pelvis, measured as the greatest perpendicular distance from the tuberosity of the ischium to the iliopectineal line.
6. Accurate cephalometry is possible when the head is sitting on the pelvic brim or when it is engaged in the inlet in the transverse position. This occurs in approximately 60 percent of cases.
7. Fetal presentation and degree of engagement.

Results

Table 1 shows that of the 317 cases assessed, no follow-up was possible in 14. On the recommendation of the obstetrical member of the team (F.J.T.), an additional 25 cases were deleted from the series for reasons such as soft tissue dystocia, uterine inertia, or when an elective caesarean section was

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performed without an adequate trial of labour. In other cases, sufficient clinical information was not available to properly assess the disproportion factor. A total of 278 cases remained in which an accurate assessment of predictions could be made.

Table 2 shows that of these 278 cases, an uncomplicated vaginal delivery was predicted in 189 on the basis of the single erect lateral film of the pelvis alone. The remaining 89 cases presented features of obvious or borderline cephalo-pelvis disproportion and therefore indicated a full pelvimetric study.

Table 1

Number of Cases Initially Reviewed		317
No Follow-up Available		14
Cases Unsuitable For Evaluation	25	39
Total Number of Cases For Assessment		278

Of the 189 cases, in whom an uncomplicated vaginal delivery was predicted, there were 8 errors of interpretation, disproportion being present at the inlet in one case and at the lower pelvic strait in seven.

Table 2

Evaluation of Erect Lateral Film of the Pelvis Alone--278 Cases

Uncomplicated Vaginal Delivery Predicted in	189
Prediction Not Possible Without Full Pelvigram Study	89

In no case was an isolated transverse contraction of the inlet responsible for an error. This is in keeping with the views of Williams[1] and others, who state that isolated contraction of the transverse plane of the inlet is rare. The prognostic value of the transverse diameter of the inlet is overshadowed by the importance of the antero-posterior diameter of the inlet, since when this latter measurement is 11.5 cms. or over, it can be assumed with safety that no cephalo-pelvic disproportion exists at the inlet. In the series under discussion, there was only one patient with an antero-posterior inlet measurement of 11.5 cms. or over, on whom a Caesarean section was necessary for cephalo-pelvic disproportion and this disproportion was due to marked lower pelvic strait contraction. When the shortest available antero-posterior diameter of the inlet is less than 11.5 cms. and the fetal head is engaging at or near term, accurate cephalometry is usually possible and will allow ready estimation of the presence or absence of inlet disproportion. When the head is fully engaged in a patient near term, it is clear that no inlet disproportion exists.

In 7 cases, lower pelvic strait disproportion was the major cause for erroneous interpretation. In 5 of these cases, there was narrowing of the interspinous diameter by prominent ischial spines projecting medially, an anatomical variant which cannot be detected on the lateral film study. In one case the significance of a rather prominent sacro-coccygeal shelf projecting anteriorly was not appreciated. In the remaining patient, lower pelvic strait disproportion necessitating mid-cavity forceps was clinically detected but was not evident on our pelvic mensurations.

Discussion

We agree with Morris[2] that the antero-posterior diameter of the outlet is the most significant measurement in the lower pelvic strait. He suggests that if this diameter is 11.5 cms. or over, no significant pelvic outlet contraction exists. In our series, however, there were 3 cases of lower pelvic strait disproportion in whom the antero-posterior diameter exceeded 11.5 cms. In one of these, the baby weighed 4650 gms. and in the other two, the obstetrician who reviewed the cases felt that there was clinical evidence of borderline disproportion. This figure of 11.5 cms. will allow for slight to moderate narrowing of the bi-spinous diameter but will not compensate for marked narrowing. We feel that an antero-posterior diameter of the outlet of under 11 cms. must be accepted with caution and that if prominent ischial spines are detected clinically, a full pelvigram study is indicated. If the subpubic arch and interspinous diameter are felt to be adequate clinically and the other pelvic characteristics as judged by lateral radiography are satisfactory, an antero-posterior diameter of the outlet of 10.5 cms. will probably prove to be adequate.

The posterior-sagittal diameter of the mid-pelvis has not proved to be a very reliable measurement in assessing lower pelvic strait disproportion. First, it is a difficult measurement to make accurately in many cases because of failure to clearly identify the ischial spines. Secondly, the possibility exists that a prominent sacro-coccygeal shelf might well be overlooked if the posterior-sagittal diameter of the mild-pelvis is normal. Most important, however, we have found no consistent

correlation between a narrow posterior-sagittal diameter and lower pelvic strait contraction. Our results clearly show that the antero-posterior diameter of the outlet is a more useful and practical measurement in the assessment of lower pelvic strait disproportion in the sagittal plane.

The difficulty of accurately predicting lower pelvic strait contraction, even on full pelvigram studies, has been emphasized by Moir,[3] Williams,[4] Allen[5] and others, and this conclusion is reflected in the present series, in which 7 out of 8 errors made in the evaluation of the single erect lateral film of the pelvis were due to lower pelvic strait disproportion.

As previously stated, evaluation of the full pelvigram study was carried out independently on the entire series. In the 278 assessable cases, there were 13 in which disproportion was present but was not predicted, and 14 where disproportion was predicted but was not evident during the course of labour.

It will be readily appreciated from the foregoing that much information of prognostic value can be gleaned from the erect lateral film of the pelvis without recourse to the traditional antero-posterior and inlet views. This conclusion is supported by the 95.8 percent accuracy of prediction in the 189 cases in the present series in whom the lateral film only was used in assessing cephalo-pelvic disproportion.

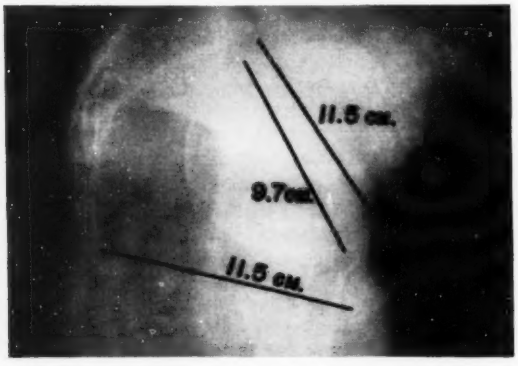

Figure 1 — Normal pelvic measurements in sagittal plane. No cephalo-pelvic disproportion evident.

It must be equally apparent that certain information, commonly regarded as an integral part of the radiological evaluation of the maternal pelvis, can be obtained only by studies made in the antero-posterior projection. We believe, however, that much of the knowledge gained by these extra views can be readily obtained by careful clinical assessment, without additional radiation exposure. The items of major importance in the transverse plane are four in number and are listed as follows:

1. *Transverse diameter of the inlet:* In the presence of an adequate antero-posterior inlet diameter, the measurement of the transverse plane of the inlet is not of major importance, as discussed above.
2. *Inter-spinous diameter:* The inability to measure the interspinous diameter is a major disadvantage of single lateral film pelvimetry. This accounted for 5 of the 8 errors on lateral film assessment. However, this disadvantage can be almost eliminated if the referring obstetrician informs the radiologist of the characteristics of the ischial spines following the initial clinical pelvic examination.

Figure 2 — Same case as Fig. 1. Supero-inferior projection of pelvis showing large ischial spines, markedly narrowing the interspinous diameter.

Figure 1 shows the erect lateral film of the pelvis made on a 23 year old primigravida at or close to full term. The shortest available antero-posterior diameter of the inlet is 11.5 cms., the antero-posterior diameter of the outlet 11.5 cms., and the biparietal diameter of the head is 9.7 cms. Furthermore, the head is well engaged in the inlet. We reviewed this film study and were entirely satisfied with pelvic adequacy in the sagittal plane. Figure 2 shows a supero-inferior projection of the pelvis, made on the same patient, demonstrating huge ischial spines projecting medially and markedly narrowing the interspinous diameter. It now is readily apparent that a head whose smallest diameter is 9.7 cms. cannot go through an interspinous diameter which measures 7.7 cms. Following a full trial of labour, this patient had a Caesarean section because of marked contraction of the lower pelvic strait in the transverse plane.

Prominent medially directed ischial spines easily identifiable on clinical pelvic assessment make full pelvimetry mandatory. This case very aptly demonstrates the danger of relying solely on the erect lateral film of the pelvis when information regarding the initial pelvic assessment is not made available to the radiologist.

3. *Subpubic arch:* The third item of importance in the transverse plane of the pelvis:

Inability to evaluate the subpubic arch radiologically is a disadvantage only if the findings of the examining obstetrician are not made available to the radiologist. When a narrow subpubic arch is noted by the obstetrician, its influence on the uncorrected antero-posterior diameter of the outlet can be accurately assessed by a special subpubic arch projection. The importance of the subpubic arch in relation to the antero-posterior diameter of the outlet has been emphasized by Morris[2]. However, we feel that a statement made by this author deserves reiteration: "as a working rule in all cases in which the antero-posterior diameter from the lower border of the symphysis to the tip of the sacrum is 11.5 cms. or over, outlet contraction is very unlikely, unless the ischial spines appear to be particularly prominent and inverted".

4. *Inability to determine pelvic shape:* It is commonly recognized that the android pelvis is the most hazardous from an obstetrical viewpoint, and android characteristics can frequently be detected on lateral film studies by a narrow angulated sacro-sciatic notch as described by Caldwell and Moloy[6]. Another characteristic of the android pelvis, as described by these authors, is an increase in pelvic depth, a feature which can readily be determined on lateral pelvic studies. When these structural android characteristics are detected on the single erect lateral film of the pelvis, unless the sagittal measurements are above the limits described, a full pelvigram study is indicated despite the absence of cephalo-pelvic disproportion at the inlet.

The following technique of pelvimetry is suggested as a safe, satisfactory, and accurate method in the initial assessment of cephalo-pelvic disproportion. The initial erect lateral film of the pelvis is examined by the radiologist after obtaining from the attending obstetrician information regarding the status of the ischial spines and the subpubic arch. If the pelvis is considered adequate on the basis of clinical and radiologic evidence no further films are made. If a confident prediction of an uncomplicated vaginal delivery cannot be made, a full pelvigram study is then carried out.

It should be recognized that there will always be a small percentage of cases in which the anticipated outcome of labour will be in error because of certain unpredictable factors, such as uterine inertia, soft tissue dystocia, unfavorable positions of the fetus, or an unrecognized large baby. It is well known that these factors will tend to aggravate the problem arising from disproportion, whereas efficient labour can overcome such problems in many instances. Therefore, it must be remembered that in some of these cases of borderline disproportion, predictions made as a result of the radiologic examination may not have a high degree of accuracy since the disproportion may be just one of several facets of the problem to be considered.

The erect lateral film studies of the pelvis in the present series were made on 14 x 17" films, with a graduated steel rule placed in the gluteal cleft. In the future, we plan to use the technique suggested by Hartley[7], which dispenses with the ruler. With this modification and with careful collimation, we expect to be able to perform lateral pelvimetry on 10 x 12" films, with still further reduction in radiation dosage to the maternal ovaries and to the fetus, without compromising the efficiency of the method.

Summary and Conclusion

The erect lateral film of the pelvis from the pelvigrams of 317 patients examined in the Royal Victoria Hospital between 1954 and 1958 have been reviewed in an attempt to determine the percentage in whom a vaginal delivery could be confidently predicted. The shortest antero-posterior diameter of the inlet and the antero-posterior diameter of the outlet were measured. The shape and inclination of the sacrum, the width of the sacro-sciatic notch and relationship of the presenting part to the inlet were evaluated. Cephalometry was done when possible.

Of the 278 assessable cases, uncomplicated vaginal delivery was predicted in 189 cases, on the basis of the single lateral film. This evaluation was correct in 181 cases — an accuracy of 95.8 percent. The major cause of error was due to failure to recognize lower pelvic strait disproportion.

With a view to reducing radiation to the maternal ovaries and to the fetus, a plea is made for the use of the single erect lateral film of the pelvis as an initial procedure in pelvimetry. Adequate clinical information regarding the prominence of the ischial spines and the width of the subpubic angle is essential for accurate interpretation and prediction of the outcome of labour. We believe that when the pertinent clinical information

is made available, this single film will exclude cephalo-pelvic disproportion in approximately two-thirds of cases.

Sommaire et Conclusion

Le cliché latéral du bassin, en position debout, de la pelvimétrie de 317 patientes examinées à l'hôpital Royal Victoria entre 1954 et 1958 a été revisé dans le but de connaître le pourcentage des cas où un accouchement par voie vaginale pouvait être anticipé avec assurance. Le diamètre antéro-postérieur le plus court des détroits supérieur et inférieur a été mesuré. La forme et l'inclinaison du sacrum, la largeur des échancrures sciatiques et les rapports de la présentation avec le détroit supérieur ont été reconsidérés. La céphalométrie a été faite lorsqu'elle était possible.

Des 278 cas répondant aux critères ci-dessus, une délivrance vaginale sans complication a été prédite pour 189 cas en se basant sur ce seul film en latéral. Cette prédiction s'est vérifiée dans 181 des cas, une précision de 95.8%. La principale cause d'erreur venait de la difficulté à reconnaître une disproportion au détroit inférieur.

En vue de réduire les radiations aux ovaires de la mère et au fétus, un appel est lancé en faveur d'un film préliminaire du bassin en station latérale précédant la pelvimétrie. Des renseignements cliniques judicieux concernant la proéminence des épines sciatiques et l'ouverture de l'angle sous-pubien sont essentiels à une bonne interprétation et à la prévision de la marche du travail.

Les auteurs pensent que lorsque l'on peut obtenir des informations cliniques pertinentes, on excluera par ce seul film en latéral une disproportion céphalo-pelvienne dans les deux-tiers des cas environ.

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A meeting of Council of the Canadian Association of Radiologists will be held June 16 and 17, 1961, at The Cardy-Alpine Inn, Ste-Marguerite, Quebec.

ASYMMETRY OF THE KIDNEYS IN DISEASE OF THE MAIN RENAL ARTERY *

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Ottawa, Ontario †

Although Goldblatt[1] in 1934 showed that unilateral renal artery occlusion in dogs produced hypertension, demonstration of this mechanism in man has proved disappointingly rare. Homer Smith[2] in 1956 reviewed the literature on 575 cases of nephrectomy for unilateral renal disease in hypertensive patients; in only 149 did he feel that the operation had cured the hypertension, and in only 14 of these was the renal lesion occlusion or aneurysm of the renal artery. He also quotes Smithwick as finding only one instance of Goldblatt kidney in 1200 patients submitted to sympathectomy.

In recent years however the increasing use of aortography has revealed many more cases of renal artery disease. Page, Dustan and Poutasse[3] report that up to 1950 no hypertensive patient at the Cleveland Clinic was suspected of having renal artery disease. From 1950 to 1954 when aortography was used only occasionally in hypertensives, 6 were found to have occlusive renal artery disease; and in a similar period from 1955 to March 1959, when aortography was used extensively in hypertensives, 87 cases of occlusive renal artery disease were found. Increasing use of aortography however has not only shown that renal artery disease is more common, but also that it is more difficult to diagnose on pyelography than was previously thought. Chief credit for this realization should go to Howard et al.[4] and Poutasse and Dustan[5] who pointed out that the intravenous pyelogram could appear normal in the presence of significant renal artery disease; this finding has been confirmed by various authors since this time (e.g. Margolin et al.[6] and DeCamp and Birchall[7]). The concentration of opaque medium on pyelography seems a particularly erratic index. Cordonnier[8] states that the dye concentration may actually appear better on the affected side. This increased concentration of opaque medium would presumably be associated with the increased osmolarity of the urine in ischemic kidneys which Schlegel et al.[9] have reported.

In view of the unreliability of asymmetry of excretion as an index of renal artery disease, more attention should perhaps be paid to asymmetry of size. Poutasse and Dustan[5] in 1956 drew attention to importance of asymmetry in length as a sign of renal artery disease and in 1957[10] they suggested that "a difference of 1 cm. or more in lengths of kidneys of a hypertensive patient may represent atrophy of the smaller kidney due to vascular insufficiency". Hodson[11] also drew attention to the importance of asymmetry in length and considered as significant the difference in length of 1.5 cm., particularly if "such asymmetry is supported by demonstrable generalized narrowing of the renal substance on the smaller side".

In assessing the significance of asymmetry however it has to be borne in mind that there is a normal asymmetry of the kidneys, the right kidney tending to be shorter and thicker than the left. This has been demonstrated both anatomically[12] and radiographically[13]. It is the purpose of this paper to determine from consideration of 100 normal intravenous pyelograms in patients with a normal blood pressure, what degree and type of asymmetry can be accepted as a normal variant, and to contrast this with the asymmetry found in 6 cases with disease of the main renal artery, shown by aortogram or demonstrated at operation or post-mortem.

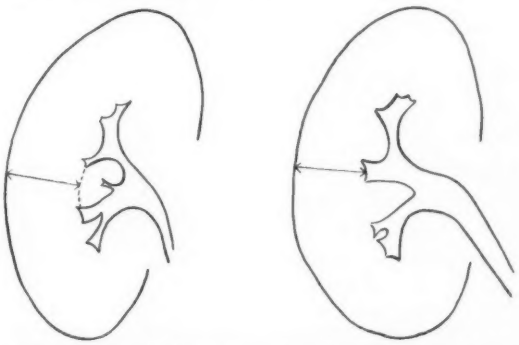

Figure 1 — Method of estimation of parenchymatous thickness.

Normal Intravenous Pyelograms

In order to obtain the control series, consecutive unselected intfavenous pyelograms were taken from the files until 100 cases with

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† *From the Ottawa General Hospital and Ottawa University, and from the Massachusetts General Hospital.*

normal pelvicaliceal pattern (excluding both congenital and acquired abnormalities), regular renal outlines and normal excretion of opaque medium were found in patients known to be normotensive. Patients with a systolic pressure over 130 or a diastolic over 80 were excluded. The lengths of the kidneys were estimated directly from the films without allowance for radiographic magnification. The thickness of the parenchyma was estimated from the tips of the papillae (that is the middle of the "cups" of the minor calyces) to the nearest portion of the renal outline. Initially the thickness was estimated at three levels, the upper pole the lower pole and the middle of the cortex (Figure 1). The measurements at the poles were however found to be inconsistent and the parenchymatous thickness was therefore recorded exclusively at mid level. The results are shown in Tables I and II. It will be seen that a

TABLE I

AVERAGE DIMENSIONS OF NORMAL KIDNEYS (100 CASES)

A Variations in length

Right kidney: 9.1 - 15.6 cms, average 12.4 cms.
Left kidney: 9.9 - 15.9 cms, average 12.8 cms.

B Variations in parenchymatous thickness

Right kidney: 1.9 - 3.5 cms, average 2.7 cms.
Left kidney: 1.6 - 3.5 cms, average 2.5 cms.

On average, right kidney { length — 0.4 cms. shorter; parenchyma — 0.2 cms. thicker }

TABLE II

ASYMMETRY IN NORMAL KIDNEYS (100 CASES)

A Asymmetry of length

Asymmetry less than 1.0 cm. — 73
Asymmetry 1.0 cm. - 2.4 cms. — 27 (over 1.5 cm. in 9/27)
In 25, shorter kidney was (R)

B Asymmetry of parenchyma

Asymmetry less than 1.0 cm. (73 cases) — parenchymatous symmetry variable
Asymmetry 1.0 cm. or over (27 cases)

shorter kidney thicker,	20
shorter kidney same,	5
shorter kidney thinner (1 mm)	2

considerable variation in normal length was found, but that in 73% of the cases, there was less than 1 cm. difference in length between the kidneys of the same subject. In 27% however there was asymmetry of 1 cm. or over, and in view of the frequency of this finding in normotensive patients with otherwise normal kidneys, it seems difficult to attribute significance to asymmetry of length alone. Considering Hodson's suggestion that asymmetry is more important if accompanied by narrowing of the renal substance, it will be seen that in 25 of the 27 the parenchymatous thickness of the shorter side was greater or the same as that on the longer kidney; in only 2 was the parenchyma thinner, and then only by 1 mm. Asymmetry if accompanied by parenchymatous thinning might therefore be of significance and these criteria were then applied to 6 cases of renal artery disease.

Cases of Renal Artery Disease

CASE 1:

This 66 year-old man was admitted to the Massachusetts General Hospital with a one-year history suggestive of hypertension, and was found to have a labile blood pressure ranging from 170/110 to 240 140. Urinary catecholamine excretion was normal.

Intravenous pyelography (Figure 2) showed normal renal outlines and pelvicaliceal patterns, with equal but rather poor bilateral concentration of opaque medium, but possibly some diminution of output from the left kidney. The left kidney is seen to be 2.7 cms. shorter than the right (10.3 cms. to 14.0 cms.), and the parenchyma was appreciably thinner (1.8 cms. to 3 cms.). Differential urinary excretion studies showed diminished urine flow and creatinine clearance from the left kidney but an increased sodium concentration. Aortography did not show the left renal artery clearly, but it appeared to be small and poorly filled and the origin of the artery was never seen opacified, so that an obstructive lesion at this level could not be excluded.

Figure 2 — (Case I) I.V.P. showing asymmetry of the kidneys, the left being 2.7 cms. shorter and the parenchyma 1.2 cms. thinner. Poor but fairly equal concentration of opaque medium bilaterally.

At operation a small mass was found in the right adrenal which was removed and found to be an adrenal myelolipoma. On the left, partial obstruction of the renal artery near its origin was found, and the mean pressure in the artery was 30 mms. of mercury, compared with a mean of a 120 in the aorta. Left nephrectomy was therefore performed. Pathological examination showed a normal kidney apart from a markedly thin cortex. The diseased portion of the artery was not removed, and the remainder of the renal artery was normal. The obstruction was presumably an atheromatous plaque. Postoperatively, the patient's blood pressure fell to 120/85, and had remained at that level when he was seen four months later.

CASE II:

This 40 year-old man ten months before admission to the Massachusetts General Hospital had been stricken with an acute attack of left lower quadrant pain. Intravenous pyelography at another hospital had been negative, and cystoscopy had shown a blood clot in the left ureteric orifice. His blood pressure, which had hitherto been normal, started to rise, and three months before admission he developed symptoms of hypertension. On admission to the Massachusetts General Hospital, he was found to have a blood pressure of 240/140 with left ventricular hypertrophy and hypertensive retinopathy. Urinary catecholamines were normal.

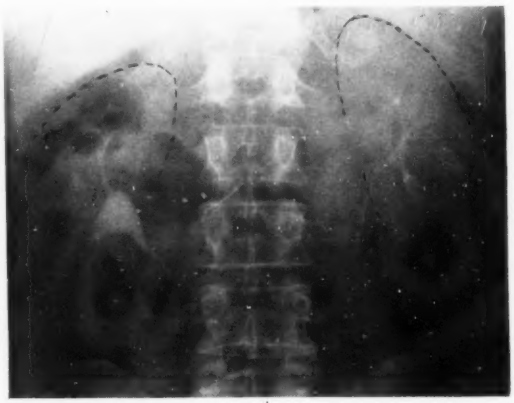

Figure 3 — (Case II) I.V.P. showing asymmetry of the kidneys, the left being 2.3 cms. shorter and the parenchyma 0.5 cms. thinner. Equal concentration bilaterally.

An intravenous pyelogram (Figure 3) showed normal renal outlines and pelvicaliceal patterns, but possibly diminished output from the left kidney. The kidneys were asymmetrical, the left kidney being 2.1 cms. shorter (12.9 to 15.0 cms.) and the parenchyma 0.5 cms. thinner (2.4 to 2.9 cms.) than on the right. Differential urinary studies showed diminished urine flow, creatinine clearance and sodium concentration from the left kidney, and aortography showed partial occlusion of the left renal artery about 1½ inches from its origin.

At operation, there was no detectable pulsation in the left renal artery, and a firm atheromatous plug was palpated at its origin. An attempt at endarterectomy having failed, the kidney was removed, and pathological examination showed an essentially normal kidney and renal arterial system. Postoperatively, the patient's blood pressure fell to 150/90, and when seen 8 months later, his blood pressure had remained at this level with remission of his symptoms and retinopathy.

CASE III:

This 72 year-old man was first seen at the Massachusetts General Hospital in 1953 because of prostatic enlargement; his blood pressure then was 145/65, and an intravenous pyelogram showed no abnormality. The kidneys were within normal limits of asymmetry, the right being 0.5 cm. longer, and the parenchyma being 0.3 cm. thinner. Prostatectomy was not considered necessary during this admission. In 1957 he was readmitted for consideration of prostatic surgery. His blood pressure was then in the region of 180/90 and intravenous pyelography showed a marked change. Marked asymmetry of both size and function had now developed, the right kidney having increased in size from 11 cms. to 12.2 with maintenance of good function, and the left having decreased in size from 10.5 to 8.7 and now showing impaired concentration of opaque medium. The left kidney was not only 3.5 cms. shorter than the right, but the parenchyma was 1.0 cm. thinner. Owing to the patient's age and general condition, he was not studied further for renal artery disease, and transurethral prostatectomy was performed. The patient however collapsed and died shortly after operation.

At the post-mortem, a shrunken left kidney with a thrombosed and completely occluded left renal artery was found; the upper pole however was not shrunken as it was supplied by a patent aberrant artery.

Figure 4 — (Case III) Composite picture, retrograde pyelogram of right kidney, I.V.P. of left. Asymmetry of the kidneys, the right being 1.8 cm. shorter and the parenchyma 0.7 cm. thinner. Poor concentration of opaque medium on right.

CASE IV:

This 50 year-old man was investigated at the Ottawa General Hospital for labile hypertension of around 230/120. This hypertension was known to have been present for some years, and a few years previously, the patient had suffered a mild stroke.

The intravenous pyelogram (Figure 4) showed asymmetry of the kidneys, the right kidney being 1.8 cms. shorter, (10.6 - 12.4) and the parenchyma being 0.7 cms. (2.1 - 2.8) thinner than the left. There was markedly impaired concentration of opaque medium on the right side, but a retrograde pyelogram showed a normal pelvicaliceal pattern. Differential urinary function studies showed diminished urine volume and phenolsulfonthalein excretion from the right kidney.

Renal arteriogram (Figure 5) showed almost complete obstruction of the right renal artery, the narrowed segment at the origin of the renal artery being 1.8 cms. in length, with post stenotic dilatation. In view of the patient's prolonged hypertension and previous stroke, operation was not advised.

CASE V:

This 56 year-old man had been admitted on several occasions to the Ottawa General Hospital for arteriosclerotic heart disease with congestive cardiac failure and auricular fibrillation. In view of a blood pressure of 190/110, intravenous pyelography was performed, (Figure 6), and showed normal pelvicalyceal patterns and renal outlines, but asymmetry of the kidneys, the right kidney being 2.5 cms. shorter (12.1 - 14.6), and the parenchyma 1.4 cms. thinner (2 - 3.4) than the left. Renal artery disease was therefore suspected and an aortogram performed, (Figure 7); this showed complete

non-filling of the right renal artery, and a shallow filling defect in the aorta at the expected level of the origin of the right renal artery. Differential urinary excretion studies showed a markedly diminished output from the right kidney, with a higher sodium concentration on the affected side. This patient refused operation.

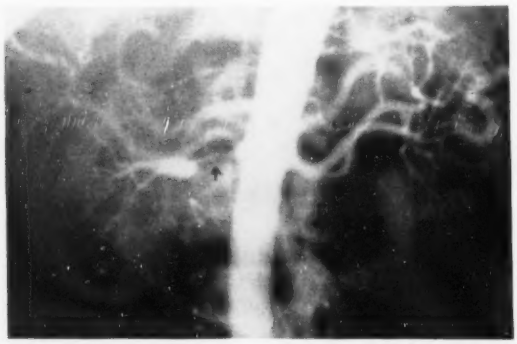

Figure 5 — (Case IV) Renal arteriogram showing almost complete obstruction of the right renal artery with post-stenotic dilatation.

Figure 6 — (Case V) I.V.P. showing asymmetry of the kidneys, the right being 2.5 cms. shorter and the parenchyma 1.4 cm. thinner. Good and equal concentration of opaque medium bilaterally.

CASE VI:

This 60 year-old female patient was investigated at the Ottawa General Hospital for a hypertension of about 220 100. Intravenous pyelography (Figure 8) showed normal pelvicalyceal patterns and renal outlines but asymmetry of the kidneys, the left kidney being 1.1 cm. shorter and the parenchyma 0.4 cm. thinner than the right. Differential urinary excretion studies showed equal volume on the two sides but a depressed sodium concentration on the left side. An aortogram (Figures 9, 10 and 11) showed an apparently complete occlusion of the left renal artery at its origin, circulation in the artery being maintained by a profuse collateral circulation. By 3 seconds after injection, opaque medium was almost completely absent from the right renal arterial system but could still be seen entering the left renal artery through the left collateral circulation. By 5 seconds after injection, the aorta and the right renal artery were completely empty but opacified collateral circulation could still be seen in the right kidney. A poor nephrogram could also be seen on the left side.

Operation was considered inadvisable owing to the presence of elevation of the blood urea, which presumably indicated bilateral impairment of renal function.

Figure 7 — (Case V) Renal arteriogram showing complete occlusion of the right renal artery with a shallow filling defect in the aorta at the expected level of the origin of the right renal artery. Faintly opacified artery overlying the right kidney is probably the cholecystic artery.

Figure 8 — (Case VI) I.V.P. showing asymmetry of the kidneys, the left being 1.1 cm. shorter and the parenchyma 0.4 cm. thinner than the right. Good and equal concentration of opaque medium bilaterally.

Discussion

Reviewing these findings, it can be seen that in the 6 cases of renal artery disease, the concentration of the opaque medium was obviously impaired on pyelography in only 2, and the concentration appeared equal in 4. In all 6 cases however, the affected kidney was shorter by over 1 cm. (1.1 to 3.5 cms.), and the parenchyma was appreciably thinner (0.4 to 1.4 cms.). These findings contrast

with those in the control series, in which if a kidney was 1 cm. or more shorter than its fellow, the renal parenchyma was usually thicker, and at most only 1 mm. thinner. It is suggested therefore that asymmetry of length of normal kidneys is in itself of no significance. If asymmetry of the kidney is accompanied by parenchymatous thinning of the shorter kidney of 3 mms. or more, this is suggestive evidence of main renal artery disease, and an indication for aortography, irrespective of a good concentration of opaque medium on the affected side.

Figure 9 — (Case VI) Aortogram, end of injection. Apparent occlusion of origin of left renal artery with profuse collateral circulation to renal artery beyond obstruction.

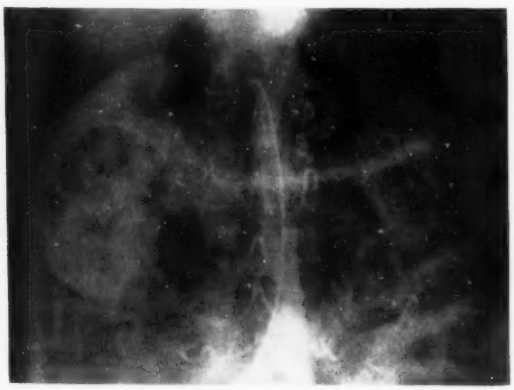

Figure 10 — (Case VI) Aortogram, 3 secs. after end of injection. Opaque medium almost completely cleared from right renal artery, but still reaching left, apparently through collateral supply. Poor left nephrogram.

It might be asked whether the absence of these signs indicates absence of a renal artery lesion, and renders aortography unnecessary; previous reports of normal pyelograms in renal artery disease having been made without awareness of the significance of this type of asymmetry. The answer to this seems to be unequivocally negative for the following reasons. Firstly, observers as aware of the significance of minor changes as Poutasse have stated that there may be no changes on the pyelogram. Secondly, the renal artery lesions may be bilateral, with bilateral and possibly symmetrical changes in the kidneys. Thirdly, the renal ischemia may be produced by a small branch of the renal artery, with no changes in the renal size, and localized changes in the renal parenchyma which may be on the front or the back of the kidney without producing any change in renal outline in the antero-posterior view. The next case illustrates this point.

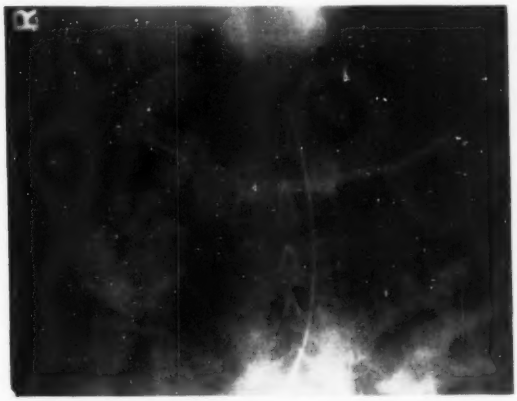

Figure 11 — (Case VI) Aortogram, 5 secs. after injection. Opaque medium completely cleared from right renal artery, but still reaching left through collateral circulation. Still poor left nephrogram.

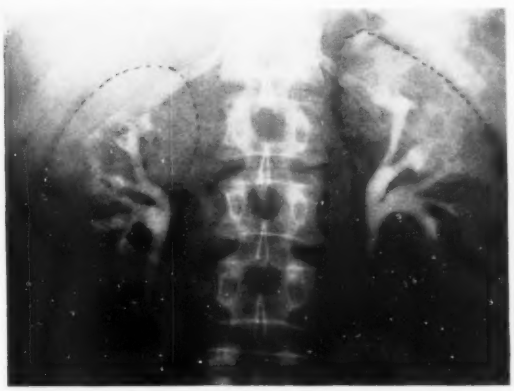

Figure 12 — (Case VII) I.V.P. showing normal and symmetrical kidneys.

CASE VII:

The patient was a man of 38, who developed hypertension 3 months after appendicectomy at which an abnormal appendix had been removed.

Tests for pheochromocytoma had been repeatedly negative, intravenous and retrograde pyelograms had been normal, and sodium and water excretion were equal and normal on both sides. He had been admitted to another hospital, where aortography was not considered indicated in view of the normal pyelograms and differential urinary excretion. He was admitted to the Ottawa General Hospital, and an intravenous pyelogram (Figure 12) was again done and showed normal and symmetrical kidneys with regular renal outlines and no parenchymatous thinning. In view of his convincing history however, aortography was performed (Figures 13 and 14), and an aneurysm of a branch of the right renal artery was shown, with ischemia of the lower pole. When this kidney was removed, in addition to the renal artery aneurysm, there was an infarct of the right lower pole which had produced marked parenchymatous thinning on the anterior aspect of the lower pole, but no change in the renal outline as viewed from the anterior aspect. Postoperatively, the patient's blood pressure fell to normal, and had remained so when he was seen 1 year later.

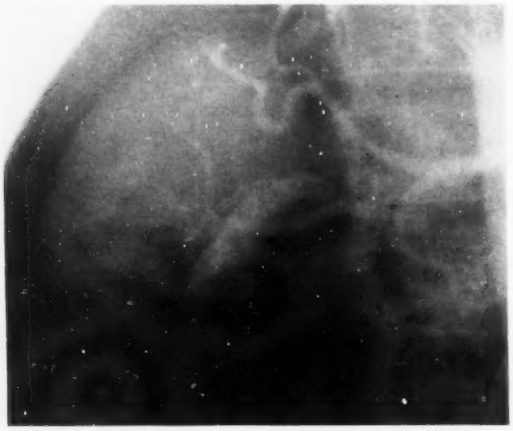

Figure 13 — (Case VII) Aortogram (2nd injection, oblique view) showing aneurysm of branch of right renal artery supplying lower pole.

Figure 14 — (Case VII) Aortogram (1st injection, A.P. view). Nephrogram phase showing ischaemia of right lower pole.

Summary

Asymmetry of the kidneys has been suggested as a sign of renal artery disease. From a consideration of 100 normal intravenous pyelograms, it would seem that asymmetry in length alone, even when 1 cm. or more, is a frequent finding and not in itself of significance. Consideration of 6 cases of main renal artery disease would however suggest that asymmetry of length of 1 cm. is significant if accompanied by parenchymatous thinning of the shorter kidney. Absence of these findings does not preclude a renal artery lesion.

Résumé

L'asymétrie des reins a été suggérée comme un signe d'une atteinte d'origine artérielle.

Après étude de 100 pyélographies intraveineuses normales, il semblerait que l'asymétrie du point de vue de la longueur seulement, même de 1 cm. ou plus, est de constatation fréquente et dépouvue de signification propre.

L'étude de 6 cas de maladie d'une artère rénale principale suggérerait toutefois qu'une asymétrie en longueur de 1 cm. devient significative si elle s'accompagne d'un amincissement du parenchyme du rein le plus court. L'absence de ces signes n'exclut pas la possibilité d'une lésion de l'artère rénale.

ACKNOWLEDGMENT: My most grateful thanks are due to Dr. L. L. Robbins, Chief of Radiology, Massachusetts General Hospital, for kind permission to publish the 3 cases from the Massachusetts General Hospital.

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Normal Radiographic Anatomy, by Isadore Meschan, M.A., M.D., W. B. Saunders Company, Philadelphia and London, 1959.

Radiation Therapy of Early Prostatic Cancer, by R. H. Flocks, M.D. and D. A. Culp, M.D., Charles C Thomas, Publisher, Springfield, Illinois, The Ryerson Press, Toronto, 1960.

KARTAGENER'S SYNDROME — REPORT OF ONE CASE

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St. Mary's Hospital
Montreal, Quebec

In 1933 Kartagener[8] reported four cases of a syndrome which subsequently has been referred to by his name. In its pure form, the syndrome consists of:

1. Situs Viscerum Inversus.
2. Bronchiectasis.
3. Chronic sinusitis and or nasal polyposis.

Seven more cases were added by Kartagener and Horlacher[9,10] in the following two years. In subsequent publications, the definition of Kartagener's syndrome has been widened to include cases with dextro-cardia[2] instead of situs inversus totalis, atelectasis[2,15] and bronchitis[9,15,16] instead of bronchiectasis, and absent or under-developed sinuses[7,13,16] replacing sinusitis.

In his original paper, Kartagener referred to a few sporadic similar cases reported in the literature. His undeniable merit, however, was to draw attention to the common occurrence of the triad. The syndrome became more and more frequently recognized, and in 1956, Kartagener and Mully[11] estimated the number of published cases at about 216. Cases not included in their paper[11] or published since, were reported by Gross[5]: one concerned a 67-year old male with a typical triad and the second, a 38-year old female with situs inversus, tubular and saccular bronchiectasis, and retention cyst in the right antrum. Deutsch[1] described one case of a 21-year old male presenting a typical Kartagener's syndrome and coincidental rheumatic fever. Gudbjerg[6] mentions 31 cases in his paper. Nichamin[15] recorded the youngest case of Kartagener's syndrome in the literature. It concerns a newborn infant presenting situs inversus, atelectasis of short duration, purulent nasal discharge, sinusitis and bronchitis, but no bronchiectasis. Overholt and Bauman[16] reported two cases in siblings: one 5-year old girl with situs inversus, absence of frontal and underdevelopment of other paranasal cavities, and her 14-year old sister, presenting bronchiectasis, nasal polyp, agenesis of frontal and underdevelopment of other sinuses. Gorham and Merselis[4] studied 29 members of one family over four generations. Among them they found two cases in siblings. In 1959, Streete and Stull[17] reported one case of a typical Kartagener's syndrome in a 14-year old girl.

Case Report

A 34-year old white female was admitted to St. Mary's Hospital with the presenting complaints of chest pain, chronic cough, abundant expectoration, and difficult breathing. Her family history was non-contributory. She is married and has one healthy child. Since her early childhood, "as long as she could remember" the patient had respiratory troubles, consisting of frequent colds, chronic, productive cough with purulent yellow-greenish sputum, and nasal discharge. She had a full scale of childhood diseases: measles, scarlet fever, chicken pox, mumps, whooping cough and otitis. She underwent tonsillectomy at the age of 7. She was subject to frequent bronchitis and sinusitis, and at the age of 18 she had pneumonia and pleurisy. At the age of 22 she was investigated in another hospital and was told that she had total situs inversus and bronchiectasis. She never had hemoptysis, night sweats, or loss of weight. At the age of 23, the patient was admitted to St. Mary's Hospital for appendicitis. The appendix was removed through a left McBurney incision and during the operation, the surgeon confirmed transposition of the abdominal viscera. The chest roentgenogram from this admission (Figure 1) shows situs inversus, heavy left lung root shadows, and increased lung markings in both lower lungs. The film of the paranasal

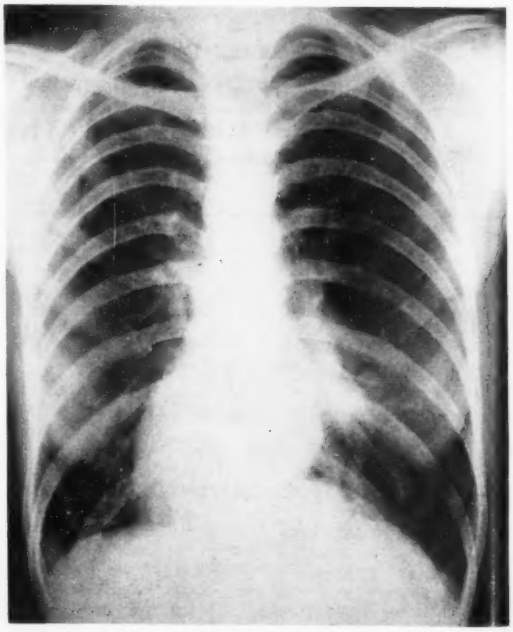

Figure 1 — P. A. Chest Roentgenogram in 1948. Dextrocardia. Infiltration in the left subhilar region, and to a lesser degree, in the right base.

sinuses (Figure 5) showed well developed cavities, slight haziness of the right antrum and a small osteoma in the right frontal sinus. The patient was readmitted to St. Mary's Hospital at the ages of 27 and 28 for fracture of the right femur and treatment of right knee ankylosis. On each occasion, ausculation of the lungs disclosed wheezes and râles, but the chest film (Figure 2) showed no appreciable change in the thoracic status.

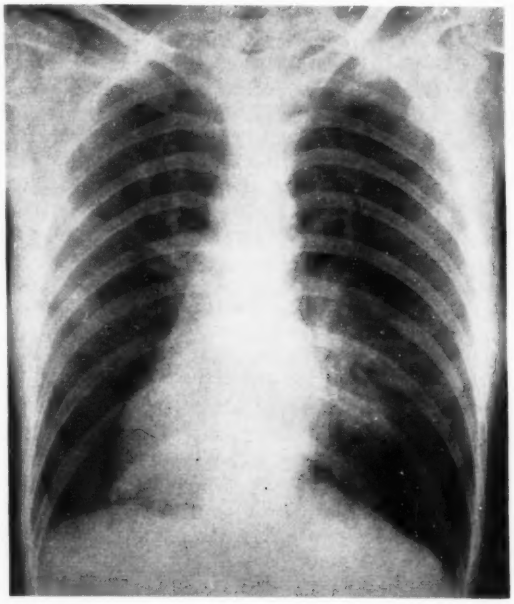

Figure 2 — P. A. Chest Roentgenogram in 1951. No significant change in the thoracic status as compared with Figure 1.

On the present admission, the blood pressure and temperature were normal. The pertinent features of the physical examination may be summarized as follows: Situs inversus, congestion of the nasal mucosa and small polyp in the right nasal cavity, rhonchi and râles on auscultation of the lungs, no clubbing of the fingers. The serology was negative. Urinalysis was negative, except for a trace of sugar on one occasion only. The WBC was 13.200 with 90% neutrophiles, 6% lymphocytes, and 4% monocytes. The bacteriological examination of the sputum showed a heavy growth of streptococcus lactis, a moderate growth of Neisseria, and a slight growth of staphylococcus pyogenes. Radiographs of the paranasal cavities yielded the same results as in Figure 5. The film of the chest (Figure 3) besides situs inversus, showed this time a sharply defined triangular density adjacent to the left hilum and diagnosed as atelectasis of the left middle lobe. The lung markings remained moderately exaggerated in both bases. Bronchoscopy confirmed the inversion of the lobar distribution and showed copious secretion in the left middle lobe and both lower lobe bronchi. Bronchography (Figure 4) showed extensive saccular bronchiectasis in the left middle lobe and saccular and cylindrical bronchiectasis in the left and right lower lobes. Operative removal of the left middle lobe and the basal segments of the left lower lobe was carried out. Her recovery was uneventful and she was discharged, markedly improved, on the 10th post-operative day. A few weeks later she developed empyema with fistula from which she only slowly recovered

The patient gave up smoking and was rewarded by decrease in cough and expectoration. In view of the cessation of smoking it is not entirely clear whether, or to what degree, the improvement is due to the surgical intervention.

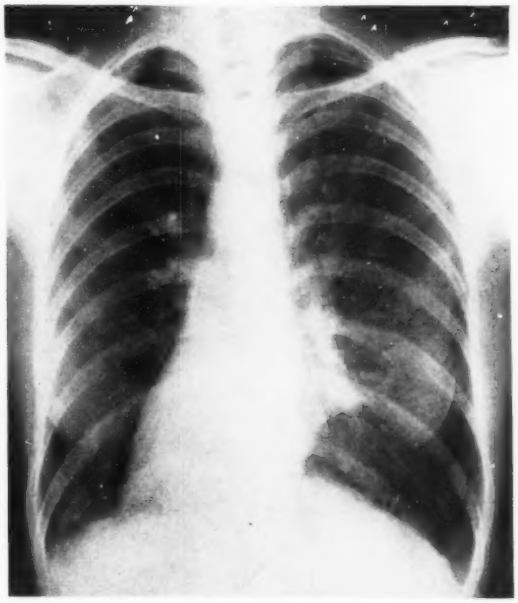

Figure 3 — P. A. Chest Roentgenogram in 1959. Atelectasis of left middle lobe. Right basal infiltration.

The pathological report was:

Specimen: 1. Middle lobe of lung. 2. Lower segment of left lower lobe. Gross: 1. Specimen consists of a portion of middle lobe measuring 7x5x2 cms. and weighs 30 grms. The lung parenchyma is atelectatic and contains dilated bronchi filled with mucous plugs. 2. Specimen consists of a basilar portion of the left lower lobe which measures 10x8x4 cms. and weighs 115 grms. There are areas of atelectasis. Many of the bronchi have dilated areas and are filled with mucous plugs.

Microscopic: 1. The middle lobe contains markedly dilated bronchi, lined by intensely secreting cylindric cells. There is marked hyperplasia of the mucous glands. The submucosa shows round cell infiltration. The alveoli are mostly replaced by fibrous connective tissue. Some dilated or cystic alveoli are seen lined by cuboidal cells.

There are also markedly atrophic alveoli surrounded by fibrous connective tissue. Some of them are filled with desquamated foamy alveolar cells. 2. Dilated bronchi are seen. There is marked peribronchial round cell infiltration with fibrosis. In some areas the alveoli are dilated and the alveolar walls are broken down. There are alveolar cells in the lumina, some of which contain brown pigment granules. Diagnosis. Left middle lobe: bronchiectasis, fibrous induration, chronic pneumonitis. Left lower lobe: emphysema and bronchiectasis.

To sum up: 34-year old housewife suffering since infancy from frequent colds, bronchitis and chronic productive cough with purulent sputum and sinusitis. Multiple examinations and surgical interventions have disclosed: Situs viscerum inversus, saccular and cylindrical bronchiectasis, right antral sinusitis, small nasal polyp and small osteoma in the right frontal sinus.

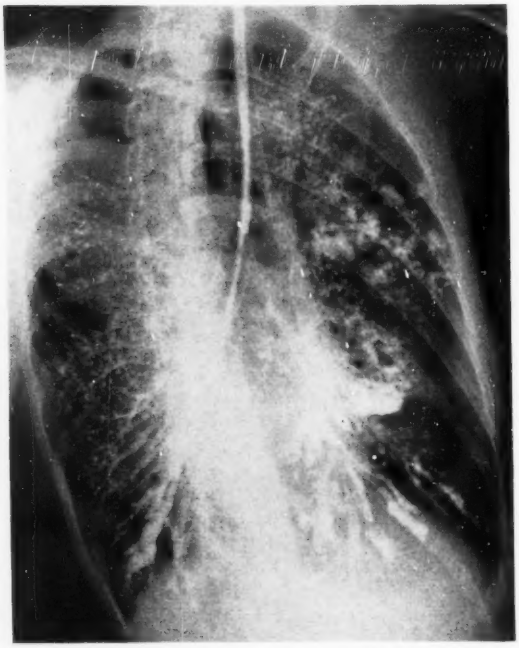

Figure 4 — Bronchography. Bronchiectasis in the left middle and both lower lobes.

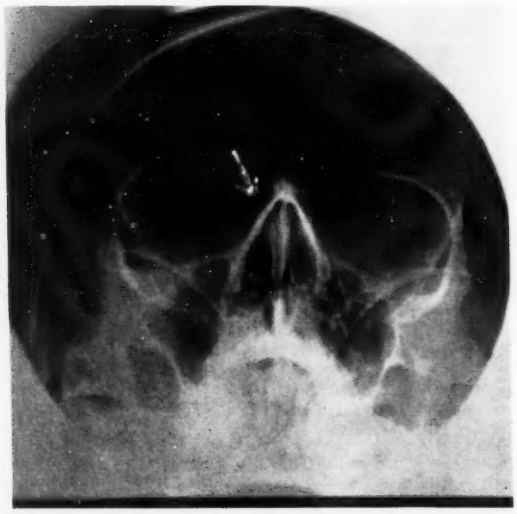

Figure 5 — Normal development and translucency, of the paranasal sinuses. Small osteoma in the right frontal sinus.

Summary

Kartagener's syndrome poses a few interesting pathogenetic problems.

(1) Is the association of Situs inversus and bronchiectasis accidental? Kartagener and Horlacher[9] found 7 cases of bronchiectasis in 30 cases of situs inversus (23.3%). Gross[5] gives statistics based on 262,000 admissions to the State of Wisconsin General Hospital between 1922 and 1952: 13 cases of situs inversus (0.005%) were found, and among them 3 (23%) presented Kartagener's Syndrome. These and other quite similar statistics quoted in the literature lend support to the idea that the association of these two features is more than accidental. On the other hand, Gudbjerg[6] studied 12 cases of dextrocardia and 13 cases of situs inversus. Although these patients had no bronchographic examinations, the absence of clinical manifestations and the appearance of plain chest films make him question the intimate association of these two features.

(2) Is there a relation between bronchiectasis and chronic inflammatory and hyperplasic lesions of the sinuses and the nose? The association of these two symptoms, whether in Kartagener's triad or not, is quite frequent. Gudbjerg[6] quotes in his paper statistics varying from 42.5% to 89.3% in favor of common occurrence of these two symptoms. His own study is based on a group of 35 selected bronchiectatic patients, among which ten (28.6%) had sinusitis. He estimates that in non-selected patients the association will fall to about 20% of cases. Dickey[2] and Gudbjerg[6] think that bronchiectasis precedes sinusitis which results from infection by septic material from dilated bronchi. Ferrand et al.[11] and Karani[7] think, on the contrary, that sinusitis precedes bronchiectasis. Indeed, in the case of a newborn infant reported by Nichamin[15] the sinuses were involved whereas the bronchography failed to demonstrate bronchiectasis.

(3) Is bronchiectasis in Kartagener's syndrome congenital or acquired? The opinions expressed by various authors are diametrically opposed. Kartagener and his successive associates[8,9,10,11,12] believe firmly that bronchiectasis is congenital in origin. Its common occurrence with situs inversus and other congenital malformations lends support to this thesis. The familial tendency of Kartagener's syndrome is another argument in favor

of a congenital origin[2,4,7,16]. The antagonists object that bronchiectasis in situs inversus were not demonstrated as yet in foetuses or newborn. Indeed, the case reported by Nichamin[15] concerning a newborn infant with Kartagener's syndrome showed no evidence of bronchiectasis. Fleischner[3] suggested that bronchiectasis may develop following atelectasis. Gudbjerg[6] concludes that clinical, radiological, and experimental evidence suggests acquired origin of bronchiectasis which is caused by obstruction and compression of the bronchi with infection superadded.

How can these opposing views be reconciled? Dickey's[2] theory is that cardiovascular anomalies favour development of atelectasis which, in turn, causes bronchiectasis, followed by sinusitis. Kartagener[12] believes the atelectasis is secondary to bronchiectasis and the study of consecutive chest films of our patient lends support to this idea. Overholt and Bauman[16] invoke an antenatal influence in the pathogenesis of Kartagener's syndrome, but believe that bronchiectasis and sinusitis develop after birth.

Kartagener and Mully[11], Karani[7] and Dickey[2] suggest that faulty development of supporting muscular, elastic and cartilaginous tissues of the bronchial wall, or secretory hyperactivity of the mucosa lining the bronchi, may be responsible for the genesis of bronchiectasis.

Challenging as these speculations may be, they do not overshadow the practical interest of Kartagener's Triad. The syndrome is easily recognized clinically. It is predominant in females. The history reveals usually frequent colds, respiratory infections with productive cough, nasal discharge, post-nasal drip of long duration, often since earliest infancy or childhood. The situs inversus is easily demonstrated. Auscultation of the lungs invariably reveals rhonchi and râles. Rhinological examination will frequently reveal sinusitis, congestion of the nasal mucosa and nasal polypi. Clubbing of fingers may be present. The syndrome is readily confirmed by appropriate roentgenologic examinations. The treatment advocated consists of resection of involved broncho-pulmonary segments. In our case, surgical removal of the involved lobes on one side (the left) was done and was followed by some improvement. It is not entirely clear, however, how much of the improvement was due to the surgery.

Résumé

Le syndrôme de Kartagener consiste en situs viscerum inversus, bronchiectasie et sinusite ou polypes nasaux. Il existe des variations de cette triade. L'histoire d'un cas typique et la revue de la littérature servent de base pour la discussion du syndrôme. L'association des symptômes dans le syndrôme de Kartagener semble sur la base des statistiques, plus qu'accidentelle. Les conceptions pathogénétiques ont été discutées. Cliniquement le syndrôme est caractérisé par toux et expectoration abondante, rhumes et accident pulmonaires fréquents, datant souvent depuis l'enfance. La démonstration radiologique n'offre aucune difficulté. Le traitement préconisé consiste en hygiène respiratoire et résection de segments pulmonaires atteints de bronchiestasie.

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BOOK REVIEWS

Cerebral Angiography in the Management of Head Trauma, by Charles A. Carton, M.D., The Ryerson Press, Toronto, Ontario, 140 pp., 1959.

This monograph is publication #336 of the American Lecture Series. It is an excellent book, well arranged and well written. The preface and introduction clearly state the background and purpose of the work. The review of the literature is broad yet concise. The 103 angiographic examinations on which the main part of the book is based are briefly analyzed in Chapter II and analyzed in detail in Chapters III and IV. Chapter V discusses the deaths and complications in the series and is followed by a summary of the case histories of all of the patients. Publication of such case summaries is often neglected, yet such information is essential for critical evaluation of the work presented.

The book suffers from rather poor illustrations. It also suffers from loose use of words such as "no pathology found" and "normal angiogram" when what is meant is "no hematoma found" or "no hematoma demonstrated". The phrases "intracortical hematoma" and "diffuse cerebral atrophy" are used in misleading fashion. Some radiological terms are incorrect. For example "right and left anterior oblique views" instead of "right and left posterior oblique views"; "reverse Towne view" instead of "Towne view".

The interpretation of the radiographic findings is occasionally incorrect. Case 5 (b) is interpreted as a subtemporal hygroma of six weeks duration and the skull films are said to be negative. Actually the left middle fossa of the skull is greatly expanded, suggesting that the hygroma had been present since early life. Case 7 is said to show minimal anterior cerebral shift. Actually it is shifted at least 1 cm. to the left but on the film the face is rotated to the left so that the shift is difficult to appreciate. There are a few inconsistencies. For example, failure of the return of the midline structures to normal position after removal of a clot is sometimes interpreted as evidence of cerebral edema, sometimes interpreted as lack of expansion of the brain and sometimes interpreted as recurrent clot.

Such minor criticism is far out-weighed by an otherwise fine work. The reviewer finds he cannot evaluate minor shift of the middle cerebral artery and its branches as well as the author does. However, to a skilled and experienced person, minor abnormalities may be informative.

D.L.M.

British Medical Bulletin, Volume 16, No. 2, The Thyroid Gland. This issue of the Bulletin contains fifteen articles devoted to the biochemistry, physiology, and some aspects of the pathology of the thyroid gland. Each contribution is written by an acknowledged authority in the pertinent field and an attempt is made to bring the reader up to date in current thinking on important developments.

Of particular interest to the radiologist is the survey by Dr. A. W. G. Goolden on the use of radioactive iodine in the diagnosis of thyroid disorders. He has submitted a fairly comprehensive analysis of the various methods of studying thyroid function with radioactive iodine, including its use in combination with drugs and hormones.

The material presented deals largely with fundamental research in thyroid function, rather than with clinical practice, and will be found most useful by the serious student of the thyroid gland.

T.A.W.

Medical Radiographic Technic, Prepared by Technical Service X-Ray Department, General Electric Company, under the editorial supervision of the late Glenn W. Files, Second Edition, The Ryerson Press, Toronto, Ontario, 365 pp., 1959.

This excellent work, the first edition of which appeared in 1943, presents a very liberal cross-section of information required by both student and practising technicians. To the student it supplies definitions and straightforward explanations of many phases of the subject. The practising technician will find it useful as a reference, particularly from the standpoint of calibration of equipment and improvement of the quality of radiographs in any radiological department.

Since the eleventh printing of the first edition, (1957), a new chapter describing special procedures has been added. Here all types of special procedures used in each system of the body are defined and explained briefly. Appropriate illustrations add much to the value of this chapter.

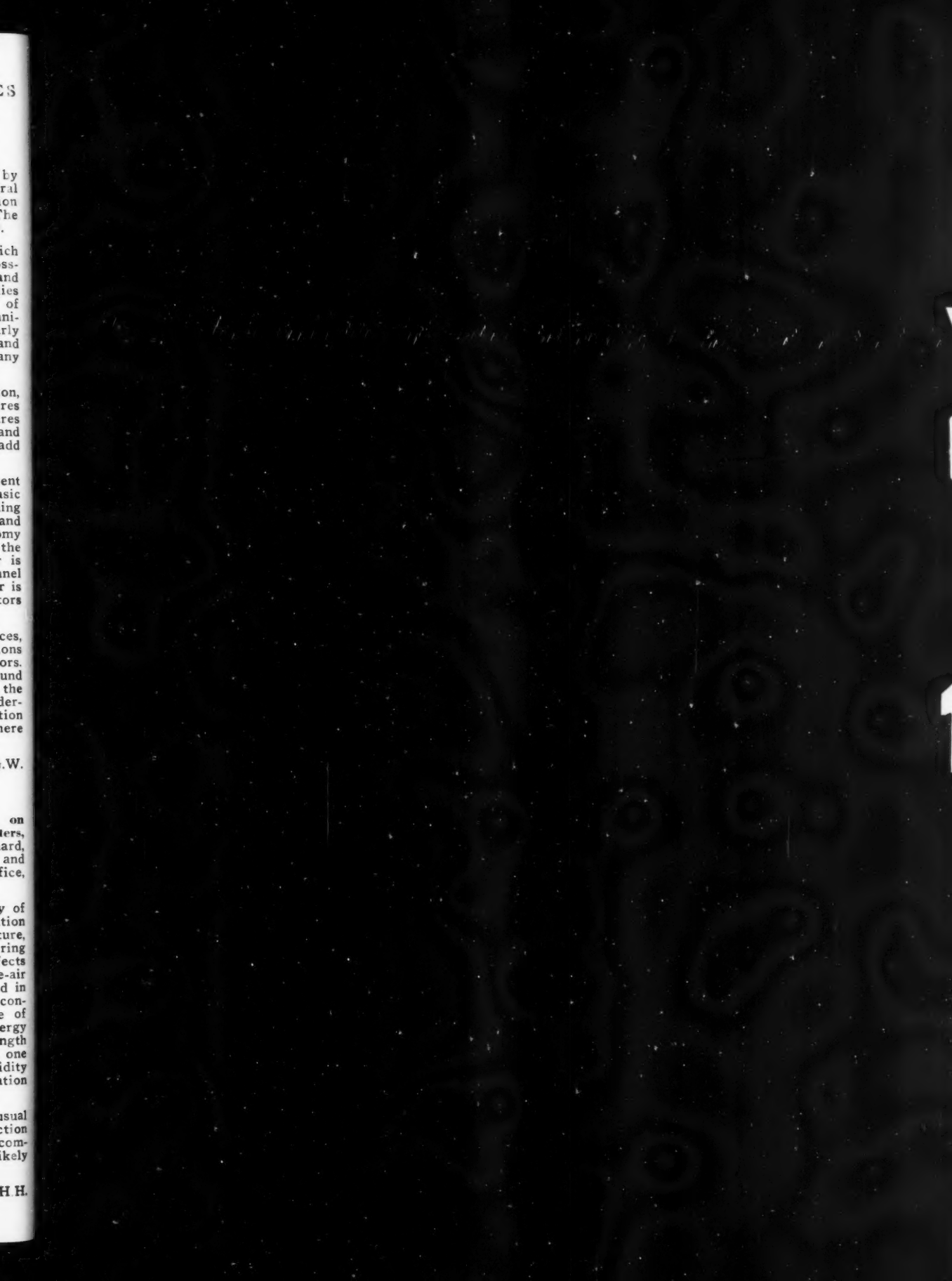
The book is especially adequate in its treatment of the "physical aspects of radiography", i.e. basic physics and basic photographic principles, including excellent chapters on body section radiography and stereoscopy. The chapters on dealing with anatomy and positioning are profusely illustrated, but the general description is superficial. No chapter is devoted to protection of the patient or personnel from excessive radiation, but the subject matter is covered in general terms in the discussion of factors affecting the quality of the radiograph.

For teaching purposes, no one book suffices, since the student must be exposed to discussions on the same topic or topics by different authors. "Medical Radiographic Technic" will be found particularly useful in this respect because of the ease with which the subject matter can be understood. It is recommended as an excellent addition to the libraries of technical training schools where students may have ready access to it.

D.G.W.

Effects of Variations in the Ambient Air on the Calibration and Use of Ionization Dosemeters, National Physical Laboratory, by G. P. Barnard, D.Sc., Ph.D., G. H. Aston, M.A., Ph.D., B.Sc. and A.R.S. Marsh, Her Majesty's Stationery Office, London, 1960.

This pamphlet undertakes a thorough study of the corrections which must be applied to ionization chamber measurements owing to the temperature, pressure and humidity of the ambient air differing from standard conditions. In particular, the effects of humidity on the response of standard free-air chambers and of cavity chambers are examined in detail. The authors include in their study a consideration of the effects which the presence of water vapour has on electron density, photon energy absorption, average energy loss per unit path length for electrons, and energy required to produce one ion pair. The calculated corrections due to humidity only will be of interest especially to standardization laboratories.

Included for completeness are tables of the usual density factors for dry air. These, in conjunction with the tabulated humidity corrections, cover completely the range of ambient air conditions likely to be encountered.

W.H.H.